

THE AMERICAN JOURNAL OF PHARMACY

APRIL, 1913

THE ASSAY OF HYPOPHOSPHOROUS ACID.

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It is proposed to neutralize hypophosphorous acid with barium hydroxide, collect any precipitate that forms on a filter and weigh after ignition. The weight in milligrams per gram of absolute acid is termed the barium number. By this means, samples containing excessive amounts of foreign acids (sulphuric, oxalic, tartaric, phosphoric, phosphorous) are readily detected. In the writer's

ANALYSES OF COMMERCIAL HYPOPHOSPHOROUS ACID.

Sample	Acidity as hypophosphorous acid	Barium number
No. 3548.....	29.73 per cent.	5.1
No. 3592.....	31.33 per cent.	6.9
No. 3636.....	31.42 per cent.	36.6
No. 3979.....	31.33 per cent.	12.3
No. 4400.....	31.20 per cent.	3.4
No. 4634.....	31.19 per cent.	4.4

opinion, an acid fit for use in medicinal preparations should have a barium number not greater than 5. Analyses of six commercial lots are given in the table. The details of the method are as follows:

Put 1 c.c. of hypophosphorous acid in a tared, stoppered Erlenmeyer flask and weigh accurately. Add 20 c.c. of water recently boiled to expel CO_2 and cooled and a few drops of phenolphthalein solution. Titrate the liquid with $\frac{N}{5}$ $\text{Ba}(\text{OH})_2$ (standardized against $\frac{N}{5}$ HCl) until a permanent pink color is produced. Put the flask in a water-oven for an hour, then collect any precipitate that may have formed on a 7 cm. Swedish filter, washing with hot water

until the filtrate no longer yields any turbidity on the addition of a few drops of dilute sulphuric acid, and burn the filter in a platinum crucible. Deduct the ash of the filter from the weight of the residue. The corrected weight in milligrams divided by the weight in grams of absolute acid indicated by the titration is the barium number.

CULTIVATION OF HYDRASTIS.

BY JOHN O. BALDWIN.

Hydrastis Canadensis L., Golden Seal, Fam. *Ranunculaceae*, is one of the most useful and valuable plants of our American forests, and so fast is the supply diminishing, that a few men have undertaken its cultivation, what success this enterprise may develop is for time to determine.

I shall in this article try to note some of the essential requirements necessary to the growth and development of this plant, referring to its history only casually.

A few years ago, as an experiment, I removed a few wild plants of golden seal from their native heath to a portion of my ginseng garden which at the time was vacant; the behavior of the plant in this experiment was eminently encouraging, and I accordingly proceeded to gather all of the wild roots and seed which I could find,—result—I now have a fine stock of growing plants under cultivation, but none for sale at this writing, as I expect to further enlarge my beds with whatever stock I may find which will do to remove this season.

The natural home of the golden seal is in the deep shady nooks of our American forests, where the soil is rich and soft and deep, and the moisture and the drainage are in its favor,—where once it grew in profusion, it is found only in patches now, and these small areas are constantly giving away to only here and there a single plant, and these lingering halos of a past wild woodland glory are, year by year, teaching their lessons of conservation to the student and grower.

To be successful in the growing of this plant, the natural conditions must be carefully and strictly observed, artificial means being employed only where they improve upon the natural, where the plants originally grew, and then, the natural conditions should not be eliminated or overlooked.

SOIL—BEDS—DRAINAGE.

The soil of my beds is a gravelly sandy loam mixed with clay; it is generally speaking, good corn ground, sloping to the north; being located upon a bank of Tinker's Creek (in northern Ohio), but above the flood line, they have an excellent natural drainage, which is necessary in the growing of this plant.

I work the soil thoroughly and deeply, in the fall, throwing out all roots, stone and coarse material, spading in well-rotted barnyard compost, vegetable leaf mould, or rotten sawdust; hence, let the beds remain until spring, again giving them the same liberal treatment, a couple of weeks before setting, giving them time to settle a little before planting out. I would here state that the soil can not be made too fertile for golden seal, neither be too soft for a good growth; it is a hardy feeder and depletes soil rapidly, but when it is well fostered and nourished it basks in its surroundings and is an easy plant to grow; therefore, imitation of the soil like unto the plant's forest home should be given strict observance when making the beds for a plant whose every nature is wild, and whom man is trying to domesticate.

Make the beds four feet wide for convenience in working, wider ones are harder to work when weeding, seeding, etc. The length of the beds is immaterial; they should be spaded and respaded, before plants are set, should be thoroughly worked over and enriched again and again, this treatment insures a good and sturdy growth. Be sure of the drainage, for the plant will not grow where the ground is wet, if there is no good natural drainage, provide for the same, and here the artificial comes in; lay a row of two- or three-inch tile lengthwise through the bed with plenty of fall and provide a good outlet and be sure this is open at all times; this drain should be about sixteen inches below the surface of the bed—in the plants' forests home the drainage was largely upward, but here under culture it must be downward, the trees and herbage of the woods absorbed large quantities of water, but under artificial shade the drainage of surplus water must be gotten rid of rapidly.

ENRICHMENT.

I have never used any kind of commercial fertilizer upon my garden—only decayed barnyard compost, rotten sawdust, and vegetable leaf mould. Therefore I can not speak intelligently re-

garding the use of commercial fertilizers in this new industry, only as I have observed their workings upon gardens other than my own. I have been successful in growing both golden seal and ginseng, and have never had, so far as I know, any disease infest my garden, or failure in any way so far as disease is concerned, having employed the above enrichments exclusively, because they are to my mind, more natural to the growth of the plant. Here, let me give the prospective grower a word of caution; some growers advise the use of hen manure, lime, wood ashes, etc., etc., etc., but I do not; the writer experimented with these during the past season, upon a small bed, and one experiment will be sufficient, for if there are any of the beautiful plants left after such a holocaust, it will be a miracle. The nearer to nature the plants can be produced, the more satisfactory will be the results to the grower; remember that these are wild plants and they are not to be domesticated in a day or in a season; their nature is wild and their growth is slow, and any thing which tends to thwart or interfere with nature,—in other words, forcing or “hustling” them, to “get the money,”—usually works disaster both to plants and grower.

PLANTS AND SETTING.

I aim to set all plants that I possibly can in the spring, so soon as I can find them; the month of May is the banner month with me, for this work, although I have set plants from early spring to late fall with fairly good results; the month of May I find by experience the best, as above stated, for it is then that the soil works best, there is just the right amount of moisture in the soil, and the weather is also right for the plants to grow and to keep on growing the whole season through, very few of them wilting after being set, and what few do, most always recover in a short time and grow.

I grade my plants into large, medium and small, or into grades of three, two and one years; proceeding to set the largest and best ones first, and so on down, by so doing I save all pieces which become broken in handling, which are also valuable, these are set with the small and one year roots and often grow into good plants later. Golden seal roots may be broken up and planted the same as the potato is cut and planted, only, if a piece is minus an eye, an eye will almost invariably form and produce a plant. I have found plants growing from the thread-like rootlets left in the ground where

a bed had been dug out a season or two previous, thus proving its sturdy persistent growth. Starting golden seal from seed is a very wearisome task, requiring some skill and considerable patience, for the seed are very slow to germinate, yet after they are once out of the ground, and after the first season they do very well with a little extra care the second year, gaining their growth rather rapidly; remove from the nursery bed, to the permanent bed when in the second season of their existence; I might add, never try to stratify *Hydrastis* seed, have a bed ready and sow them immediately after picking, covering them lightly. In setting plants take a board four feet long and eight inches wide, and lay across the bed to stand upon, so as not to tramp the bed; the edges of this board should be straight; with a garden trowel make a trench in depth necessary to the size of roots to be set, along one edge of the board, set in the plants, packing the soil firmly around them, remove the board the width of its self and repeat the operation, this leaves the rows about eight inches apart, setting them six inches in the row; leave the surface of the bed level, after which, give all a light mulch of well rotted horse manure, sawdust or forest leaves, to help hold the moisture during the long hot summer days.

ARTIFICIAL SHADE BEST.

The common slat shed, the same as used in ginseng culture, is the best for the growing of golden seal, as the plants grow better under this, than they do under trees and vines, as they have the advantage of the fertility and moisture, which trees and vines would rob them of during the growing period, the plants should have every advantage conducive to their growth at this time, because this period of their life is short; this reason alone should be in favor of the artificial shade, though other reasons might be given.

MULCHING.

Late in autumn, before the ground freezes, I cover the beds with forest leaves to the depth of two or three inches; it has been my experience that a too deep covering does more harm than good, because of field mice burrowing through the beds; when digging roots last fall (and I had noticed it before), I found quite a number of roots, especially ginseng, badly gnawed by these pests, some of

the roots were nearly eaten entire, I began an investigation, thinking that perhaps grubs were the destroyers and yet the roots showed teeth markings which grubs did not or could not do, at last I found a small run-way below the surface, and I followed this, at the end of it I found a nest of field mice huddled away as comfortable as you please, with pieces of ginseng root handy for the next meal—they were the guilty parties,—no golden seal root was found in this nest; therefore I think a light mulch to keep the frost from heaving the roots out of the ground, and just covering enough to protect them from the weather, gives to me the best satisfaction.

MISCELLANEOUS.

I do not wish nor is it my intention to antagonize anyone engaged in this industry; I have only spoken here a few words based upon my own experience; and I stand ready to adopt any improvement which gives results better than those which I already employ; I do not say that my ways or ideas are the best, but I do claim that the things which I have worked out myself, from year to year, are the most practical and are of the most value to me.

There is a tendency of a number to go into the growing of *Hydrastis*, let me say to them, like unto the army who a few years ago undertook ginseng culture and failed, that there is something to learn in this business before success is attained, unless vital things are steadfastly followed in the growing of *Hydrastis*, ruin will be the result, some writers seem to create the idea, or have a tendency to leave the impression that the cultivation of not only *Hydrastis*, but of other drug plants, is merely a haphazard, "happy go lucky" kind of a game, where one may with little effort scatter a few seeds upon earth's floor, and later reap a bountiful harvest, but I say unto all concerned, if treasures are to be reaped from the golden gathering, long earnest and persistent effort will be required before the reward of merit is obtained; to be sure a crop of golden seal can be grown in about one half the time it takes to produce a crop of ginseng, yet the grower has to know how to grow it to be successful.

Regarding quantity, a goodly number of acres will be required before the supply will overstock the market; the time will never be again, I dare say, when the cultivated root will be in quantity what the wild produced. There will always be, I predict, a sale and

at a good price for all that the grower can grow, but he must labor well and long, and in patience must he wait for it.

TWINSBURG, OHIO, February, 1913.

TINCTURE OF IODINE.*

By L. F. KEBLER,

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This commodity has probably been examined more frequently than any other simple drug offered for sale by the retail trade and I know of no medicinal agent which has more frequently been found wanting. Observations and investigations have frequently shown that when iodine was dissolved in simple ethyl alcohol there was a great tendency for the iodine to be changed into hydriodic acid and other compounds thus actually lowering the free iodine content and the diminution increased with the age of the preparation. Experiments conducted to obviate this difficulty indicated that the presence of potassium iodide tended to inhibit the usual combination of the iodine and thus increase the stability of the tincture. The method outlined for the manufacture of this commodity by the last (8th) revision of the U. S. Pharmacopœia prescribes the use of a certain amount of potassium iodide. The shortcomings of the tinctures available on the market have, however, not been materially reduced. Almost every State Board which has taken up this question has found that a large number of the samples are deficient in iodine content. This shortcoming cannot now be so fully ascribed to deterioration, neither can it be ascribed to difficulties in manufacture because the process of manufacture is extremely simple.

During the past few years a considerable number of samples of tincture of iodine have been examined in the Bureau of Chemistry. The samples shipped into interstate commerce were found to comply closely with the Pharmacopœial requirements. All of them contain the requisite amount of potassium iodide. A goodly number of samples were collected in the District of Columbia and analyzed with the following results:

* Read before the City of Washington Branch American Pharmaceutical Association, February 12, 1913, and contributed by the author.

ANALYSIS OF TINCTURE OF IODINE, RESULTS.

Iodine.		Potassium Iodide.		Alcohol.	
Grams per 100 c.c.	Per cent. Variation ¹ .	Grams per 100 c.c.	Per cent. Variation ¹ .	Per cent. Volume.	Declaration.
1.97	71.5	1.3	74	86	Correct.
3.42	50	None	100	93.5	Not declared.
4.40	36	5.38	7.5	85	Not declared.
5.04	27	None	100	94.4	Not declared.
5.08	26	3.03	40	95	Small type.
5.09	26	Trace	100	91	Correct.
5.36	22	2.1	58	95	Correct.
5.52	19.5	5.30	6	95	Not declared.
5.57	19.5	5.84	17	93.5	Not declared.
5.81	15	5.03	None	93.5	Correct.
5.88	14.5	None	100	95	Not declared.
5.89	14.5	None	100	92.8	Not declared.
6.06	12.5	6.82	36	94.5	Correct.
6.09	11	1.02	80	93.5	Not declared.
6.11	10	4.93	1	95	Correct.
6.18	10	5.37	7	91	Correct.
6.18	10	4.45	11	93	Correct.
6.24	9	4.32	13.5	88	Correct.
6.29	8	2.79	46	91	Not declared.
6.29	8	4.61	8	91	Small type.
6.32	8	2.58	48.5	91	Not declared.
6.34	7.5	None	100	93.6	Small type.
6.36	7.5	3.84	23	93.5	Not declared.
6.48	5.5	4.92	2	95	Correct.
6.48	5.5	3.81	24	88.5	Correct.
6.49	5.5	5.34	7	95	Small type.
6.73	.5	6.52	30	95	Correct.
6.75	.5	2.42	51.5	96	Correct.
6.76	.5	3.82	24	85.50	Small type.
6.78	....	2.46	51	90.5	Correct.
6.80	....	3.95	21	91	Not declared.
6.80	....	3.49	30	86.5	Not declared.
6.84	....	5.56	11	93	Incorrect.
6.85	....	5.1	2	92.72	Correct.
6.90	....	0.97	80.5	95	Small type.
6.97	.5	None	100	91.5	Small type.
7.00	2.0	5.79	16	91	Not declared.
7.03	2.5	5.52	10	91	Small type.
7.04	2.5	5.00	None	93.5	Correct.
7.18	4.5	4.58	8.5	89.5	Correct.
7.21	4.5	5.17	3	90.5	Correct.
7.21	4.5	5.67	13.5	88.50	Not declared.
7.24	5.5	5.14	3	90	Not declared.
7.58	10.5	5.12	2	94.5	Correct.
7.95	15.6	4.50	10	86	Not declared.
8.07	17.5	4.38	12.5	90	Small type.
8.11	18	3.86	23	91.50	Not declared.
8.11	18	6.00	20	95	Correct.
8.37	21.9	5.45	9	89	Not declared.
9.26	35	5.23	4.5	89.5	Not declared.

¹ N. B. The per cent. variation in above analyses is calculated to the nearest half per cent.

The pharmacopœial tincture contains "about" 6.86 grams of free iodine and 5 grams of potassium iodide in 100 c.c. The range of variation (1.97 to 9.26 grams per 100 c.c.) is certainly remarkable. What real valid excuse can be offered for either of the above extremes? Furthermore, is there any substantial reason for some of the other variations? The permissible variation from the standard must be met sooner or later. Shall it be stringent or reasonable? If reasonable shall the variation be 5 per cent. or 10 per cent. or 20 per cent.? Considering that the adjective "about" qualifies the amount of free iodine that should be present in the tincture, about 60 per cent. exceed a 5 per cent. variation, 40 per cent. a 10 per cent. variation and 18 per cent. a 20 per cent. variation. I do not believe many manufacturers will contend for or advise a 20 per cent. variation in that it would not only savor of carelessness but actually encourage it. Is then a 10 per cent. variation either way from the standard, reasonable, fair and just to the manufacturer, the consumer, the physician, etc., or is it desirable to be more stringent?

Suggestions are invited either in the columns of this journal or otherwise. The free iodine is the essential factor of this tincture but the potassium iodide and percentage of alcohol must also be considered. The conditions noted above relative to the variability of the free iodine also holds for potassium iodide. The variation ranges from no potassium iodide to 6.82 grams per 100 c.c. Discussion in this connection is also invited.

THE CHANGE FROM THE OLD TO THE NEW BOTANY IN THE UNITED STATES.¹

BY W. G. FARLOW.

It is generally known that in the seventies there was a sudden development of the study of botany in this country. Just how and why this sudden development took place at that particular date is, I suspect, not clearly recognized, at least by our younger men. From histories and reports of progress they can learn the main facts, but those who, as students or instructors, have lived through the transitional period when the old botany was changed into the

¹ Address of retiring president of the Botanical Society of America, given at the Botanists' Dinner, Cleveland, January 1, 1913.

new are in a better position to appreciate the underlying causes. There are, however, few such persons still living and the small number is not wholly due to the normal death rate. The relative number of botanists was smaller then than now and it will not do to assume that this was owing solely to the lack of attractions in the botany of the day. The main reason was that one could hardly expect to earn a living as a botanist. When I graduated from college in 1866 and wished to become a botanist, Professor Gray told me that I ought to study medicine first because the possibility of gaining a living by botany was so small that one should always have a regular profession to fall back upon. In fact, at that time medicine was practically the gate through which it was necessary to pass in order to enter the field of botany. Some years later De Bary told me that, when he was a young man, there was a similar state of things in Germany and, although desiring to devote himself to botany, he had to study medicine, taking his degree in 1853. In 1872, however, things had changed in Europe and when I went to Strassburg to study I was the only student in De Bary's laboratory who had studied medicine. The others had begun the special study of botany on entering the university and were, although no older than I was, much better trained in botany.

In 1866, there were very few botanical professorships in this country, the salaries were very small and the equipment very shabby. Gray was professor at Harvard, D. C. Eaton at Yale and Porter at Lafayette. Torrey, in spite of his distinction as a botanist, really depended on his position as a chemist for his living. The comparatively few positions in government and state stations offered few attractions and changes were frequent. To a young man the prospect was not assuring.

If we look further and ask what was the attitude of the public towards natural science, we find a state of things very difficult to appreciate at the present time. This can be illustrated by my own experience as a school boy. When I was in the high school one of the books we had to study in the upper classes was Paley's "Natural Theology." You may perhaps infer from this that the object was to give us religious instruction. Not at all. The real object was to smuggle a little human anatomy into the schools. This was the way it was done. Very few of you probably ever heard of Paley's "Natural Theology," in its way a remarkable book. In the opening chapter Paley supposes that a man walking in the fields finds

a watch on the ground. He sees the complicated machinery adapted to a definite purpose and therefore, according to Paley, at once infers that it must have had an intelligent creator. How much more strongly, therefore, should a contemplation of the organs of the human body, well adapted to perform special functions, lead us to believe in the existence of an intelligent creator. Paley then proceeds to give a rather mild account of human anatomy illustrated by plates intended to impress the readers; a ghastly head with the cheek dissected to show the parotid gland; and abdomen with the lid removed to show the bonbons inside, the stomach and spleen ingeniously arranged so as to show also the deeper lying organs, etc. Paley's reasoning does not now seem altogether convincing. If you or I had found the watch, we should have seen that it was complicated and we should have known that its purpose was to show the time of day. We should have known also that it had been made by a watchmaker. If, however, a savage who had never seen or heard of a watch had found one in the field, he would have been mystified by the mechanism and would not have had the least idea what its purpose was. Instead of recognizing an intelligent creator he would have regarded the watch itself as a god.

Now, at the time of which I am speaking, it would not have been proper to teach anatomy *as such* in the schools, but anatomy, so far as it served to show the goodness and intelligence of the creator, was quite legitimate. In other words in studying natural history one must never forget that God had made man to be the centre of the universe and all other things had been arranged for the benefit of man, and, when facts to the contrary appeared, they must be properly interpreted or denied. Since an omniscient and omnipotent being can not make a mistake, all the species of plants created in the beginning must forever remain as they were created. With this simple theory of living things people were perfectly contented until in 1859 the "Origin of Species" fell like a bomb in the camp and shattered time-worn theories. That the variations and adaptations of plants and animals were not for the benefit of man, but for the benefit of the plants and animals themselves, was a dreadful heresy. The violence of the controversy caused by Darwin's great work was something of which the present generation can have no conception. It was at its height when I was a college student. Young men were generally inclined to accept

Darwin's views, and in our college natural history society most of the meetings were spent in discussing evolution. Some of us had really read the "Origin of Species," but all were ready to talk about it. The older men, even the naturalists by profession, were much more conservative. A few adventurous spirits were more Darwinian than Darwin himself, but college professors had to be careful in what they said, for practically the whole religious world and the greater part of college graduates were not ready then to accept evolution. The bitter feeling of the anti-Darwinians continued for a considerable number of years, as is shown by the following instance. A little more than twelve years after the appearance of the "Origin of Species" one of our leading universities wished to appoint a professor of zoology. The place was offered to a friend of mine with the stipulation that he should never, directly or indirectly, refer to evolution in his lectures. As my friend was one of the most rabid evolutionists in America, the conditional offer seemed amusing. He, of course, declined and the place was then offered to one hardly less radical in his views, and was again declined. It was rumored that the place was offered to a third person and again declined, but I have no direct knowledge that this was the case. The present incumbent, I presume, believes in evolution, but probably no one has ever taken the trouble to ask him whether he does or not for, at the present day we should no more think of asking a professor of zoology whether he believes in evolution than whether he is the fortunate owner of a tooth-brush.

At a time when many of the leading zoologists, including Louis Agassiz, were strongly opposed to Darwin's views, the botanist, Asa Gray, exerted a powerful influence in converting the public to the doctrine of evolution. His simple and attractive style enabled him to reach an audience which would have been repelled by the dryness generally supposed to be characteristic of scientific writings. He was also known to be a member of the orthodox church and the good religious people of the country said: "If the orthodox Gray sees in evolution nothing inconsistent with revelation, why may we not also accept it?" Furthermore, Gray did not go too far in his views, whereas some of the evolutionists started off on a wild sea of speculation whither the public would not be expected to follow.

Having tried as far as the limited time allows to give you an

idea of the attitude of the public towards natural science, at the time when I began the study of botany, a word may be said about the botanical instruction in colleges. At Harvard botany was a required study for the whole class during half of the sophomore year. The text-book was Gray's "Structural Botany." Gray had no assistant. To require botany of a whole college class—I am not speaking of agricultural schools—is enough to condemn it to neglect and abuse. This, however, can be said of college students. If their instructors do not interest them they are always able to amuse themselves. In the corner of our lecture room was the trunk of a palmetto which had been used to grace the funeral procession of Calhoun and afterwards given by Professor Gibbs to Gray as of historical as well as botanical interest. It was the duty of the athletes while the attention of the instructor was diverted to seize the trunk and carry it to the entry and later on to start it rolling down the very winding staircase. This method of studying botany I discovered later was not confined to Harvard. Once while visiting a western university I noticed, to my surprise, a cannon ball back of a door. I asked why it was there and was told, not by a student, but by the instructor himself, that during the lectures the students rolled it along to the head of the staircase when gravity was left to do its perfect work. Afterwards some attention was paid to the lecturer, and how much was learned on any one day depends on how early in the hour the cannon ball was started on its way. Compulsory botany was not a success. In my junior year eight or ten students who really wished to study botany asked Gray to give them some instruction in systematic botany during the season when fresh material could be obtained. The work on our part was entirely voluntary and in addition to our regular work. It was not recognized by the college and we received no credit for it in the rank list. The number of voluntary workers was reduced to two in my senior year, when we had so much regular work as to leave almost no spare time. I have noticed in recent years a growing disposition to demand some reward in the shape of a degree or a certificate of some kind for any work done outside the regular curriculum. To do work for the pleasure of adding to one's knowledge is, I regret to say, getting to be a sign that one is not up to date.

On graduating I followed Gray's advice and entered the medical school, hoping sooner or later to be able to return to botany. The

opportunity came in 1870 when Gray returned from Europe. During his absence Horace Mann, Jr., who had been taking his place, died and I was then appointed assistant. I was always interested in cryptogams and, had it been possible for me to do as I pleased, I should never have studied anything but marine algæ during the rest of my life. It became my duty to arrange the thallophytes of the Gray Herbarium and the work I did was radical, I assure you. Not knowing that Littleton Island was near the North Pole, but supposing it to be somewhere in Long Island, I arranged into the waste-paper basket a number of rather shabby-looking algæ which I afterwards discovered to my mortification were very rare. It did not take long for me to find out that, whatever professors of pedagogy may say, one can not teach a subject without knowing something about it. But where was I to go to study cryptogams? It was proposed that I should study fungi with M. A. Curtis, but he died in 1872. For marine algæ I had to depend on Harvey's "Nereis" and J. G. Agardh's "Species," works which were not easily followed by a beginner, with occasional reference to the by no means exhilarating "Micrographic Dictionary."

Evidently, I must go to Europe, and Germany was the country whose universities offered the greatest facilities for my purpose. The most promising were those of Strassburg, where De Bary was professor, and Wuerzburg, where was Sachs. I chose the former rather at a venture. The other botanists there were Solms and Fr. Schmitz, then a very young man whose work had been in histology. The venerable W. P. Schimper, the bryologist and paleontologist, whose valuable herbarium had been given to the university before the Franco-German war, remained in charge of it and gave a course of lectures. My fellow students were Stahl, Rostafinski, Gilkinet, Suppanetz, an Austrian, Kemienski, who recently died at Odessa, Karl Lindstedt and Doelbruck, who died young. I learned that I was not the first American who had studied with De Bary. A short time before, while he was professor at Halle, an American, T. D. Biscoe, had taken a course in botany, although not studying botany as a specialty. The only information I have in regard to Mr. Biscoe is that he published a paper on the winter state of our duckweeds in the *American Naturalist* of 1873. There was only one other American, a law student, at Strassburg when I arrived there, for, to the surprise of my fellow-botanists I was not willing to acknowledge as a fellow-

countryman a Chilean, whose principal occupation seemed to be duelling and whose English vocabulary was limited to the two words, "damn Yankee."

The general arrangements at Strassburg were the same then as those of other German universities at the present time, but the method of working in the laboratory was very different. I was given a *Chara* to study and in a couple of hours reported that I had studied it. I was told that I had not even begun. Studying, it seems, meant that I must make sections through the scheitel and trace the successive cell-formations. But how was I to make a section and what was a scheitel? The microtome and modern methods of imbedding were then unknown to botanists and all sections had to be made by hand. The nearest approach to imbedding was in sectioning small objects like pollen grains; a few drops of mucilage were placed on a cork, the pollen mixed with it and the whole allowed to harden. Then by holding the cork in one hand one could make sections of the pollen if one were lucky. The student of the present day, when hand-sectioning seems almost a lost art, does not realize what skill in sectioning could be acquired by practice, but, like playing on a musical instrument, constant practise was heeded to keep one's hand in. Modern technique, which was borrowed by botanists from the zoologists, has of course many advantages; especially in cytological work, but, for certain work, hand-sectioning has its advantages, as, for instance, the rapidity with which sections can be made.

If I was fortunate in my fellow students at Strassburg, in one respect I was less fortunate. At the time De Bary himself was at work on his "*Vergleichende Anatomie*," which was published in 1877. Anatomical studies were not his strong point, but, in an unguarded moment, he had promised Hofmeister that he would write the volume for his series and he felt in duty bound to keep his promise. We should have preferred to have had him working on the mycological subjects in which he excelled, but the management of cell cultures and the technique required in such investigations were taught to his pupils. Rostafinski took his doctor's degree while I was in Strassburg, with the thesis, "*Versuch eines Systems der Mycetozoen*." The monograph of that group did not appear until 1875. I happened to hear De Bary and Schimper talking about Rostafinski's thesis, which they thought was a good work, although they regretted that he had made so many genera. What

would they say were they now living, when it almost seems as if we were trying to create a new genus for every species?

In the laboratory I noticed that the students seemed to refer frequently to a book of which I had never seen a copy or even heard. The book was Sachs's "*Lehrbuch*," second edition, 1870. I bought the book and was perfectly amazed. I had never dreamed that botany covered so large a field. The "*Lehrbuch*" was an admirable summary of what was known of all departments of botany up to that date, well written and excellently illustrated. The fourth edition, which appeared while I was in Strassburg, was still better. On looking at the second edition a number of years later, I noticed what seemed to be a curious omission. No mention whatever was made of bacteria. In the fourth edition they are mentioned under *Schizomycetes*. The absence of reference to bacteria in the earlier edition, however, was not an omission. There were no bacteria at that date. There were no bacteria until Cohn published his "*Untersuchungen über Bacterien*" in 1872. The fact that forty years ago Sachs had never heard of bacteria, while to-day life has almost become a burden, one hears so much about them, is a striking instance of the rapidity of development of a subject having a practical as well as a theoretical value. I know no single book which has had so great an influence in shaping the course of modern botany as Sachs's "*Lehrbuch*." It may be that the facts there given were generally known in Germany, but they were not known in other countries. On returning home by way of England in 1874, I showed my copy of Sachs to several English Botanists and it was evident that it was quite new to them. It was certainly unknown in America. If imitation is the sincerest flattery, the value of Sachs's "*Lehrbuch*" was quickly recognized, for, using it as a model or basis, there soon appeared a large number of really excellent text-books in various languages in which one recognized Sachs translated, Sachs condensed, Sachs diluted, Sachs trimmed to suit local demands. Publishers, were they capable of gratitude, would have erected a monument to Sachs's memory long ago. Draughtsmen, on the other hand, had little reason to bless his memory. Even now we can hardly open a new text-book without seeing the inevitable "after Sachs."

One evening I was present at a dinner given by De Bary. On that gay and festive occasion I heard more gossip about botanists than one hears even at a meeting of the Botanical Society of

America. My neighbors kept saying: "der schmutzige Kerl." On asking who the dirty fellow was, they said Naegeli. In my innocence I inquired what Naegeli they meant. They answered "*Der Naegeli.*" Even starch could not save his reputation, and they proceeded to tell not one but many tales which I know you are dying to hear but which I am not going to tell you. What I wish to say is this: At the same dinner some one, possibly Rostafinski, spoke of a certain Strasburger, a botanist. I understood him to refer to some botanist living in Strassburg and asked his name. I was told that he was a Pole named Strasburger who lived not in Strassburg but in Jena and had written a work which showed him to be a promising young man. That was the first time that I had heard of Strasburger, who had not then begun his work in cytology. The promise was fulfilled and the young man of 1873 became one of the bright lights of the botanical world. At the close of his long but too brief career he left a brilliant school in a department of botany which he had created and of which he remained until his death the leading spirit. Fortunately we have with us a younger generation admirably qualified to continue the work which he began.

For the last twenty years most young American botanists have thought it necessary to study in Germany to complete their education, but, when I returned in 1874, I was looked upon very much as one would be who had returned from a journey in Thibet or Central Africa. Things had changed. The country had recovered from the effects of the Civil War, money was more abundant and more could be spent on science. New professors were appointed in the colleges and courses for the instruction of school teachers in botany and zoology were provided by private individuals. I have time only to refer to one curious episode in the development of botany in America. I refer to what may be called the biological epidemic which broke out soon after I returned to America and threatened for a time to drive botany from the field. If at some future time some one ventures to write a book on the abuse of the "ologies" the chapter on biology will be the most interesting. As far as I can make out, as originally used, biology did not differ much from physiology. The laboratory manual of Huxley and Martin was planned to correct the common idea that botany and zoology consisted in the description of different species of plants

and animals, whereas in reality they are the study of plants and animals in all their relations to one another and to their surroundings. Huxley and Martin's book was extensively used in this country and was in many ways excellent. The criticism might be made that it was not well proportioned. Without saying that it was all lobster, there was so much lobster and so little of plants that there was not enough to make a good lobster salad. Soon it became the habit of young persons who knew precious little about either plants or animals to call themselves biologists, disdaining to be called botanists or zoologists. It does not follow, however, that because one is neither a botanist nor a zoologist one is to be considered a biologist. Trustees of colleges and similar institutions were given to understand that a superior race of beings had arisen, the biologists, and that botanists and zoologists had had their day. Colleges being always impecunious, this information was gladly received by their governing boards. By calling their zoologists biologists they could escape appointing professors of botany. This clever device for saving a salary worked very well for a few years, but at last it became evident that the teaching by a zoologist with the aid of a text-book, how to distinguish a yeast cell from a fern prothallus and a fern prothallus from a germinating bean, was not all that was wanted in our colleges, although it might have been sufficient in a kindergarten. The epidemic of biology, although it hindered for a time the development of botany in England and America, fortunately never spread to other countries.

Although garrulity is the privilege of old age, I feel that I am still too young to take up more of your time this evening. This occasion, in which the body as well as the soul naturally participates, seemed to me to call not so much for a formal historical account of botany in my day as for a series of personal reminiscences, more or less anecdotal in form, which would throw a little light gained from the experience of one who, although he has lived long, hopes that he has not outlived sympathy with the present, on some of the steps by which our present advanced position among the botanists of the world has been reached. It has been my fortune to see the old order of things overturned by the appearance of the "Origin of Species" which, by freeing science from the fetters of a semitheological bias, opened the way to a free scientific study of the distribution of plants and animals and the great ques-

tions of heredity and evolution. To most of you this great change is only a historical fact. To me it is a living memory. I, who was almost the first American student to seek the benefit of botanical instruction abroad, have lived to see the time when a very large number of our botanists have brought back to America the best that Europe had to offer. There was a time when our botany might have been said to bear the mark "made in England." In more recent years it may be said to have been "made in Germany." There are some patriotic souls who hope that the time will come, if it has not already come, when we may say "made in America." I do not share their feeling. To me it seems that botany is destined to become more and more widely diffused until it becomes world-wide and it will be enough if we contribute our proper share to the general stock. I have lived to see the growth of several branches of botany which practically were not studied at all when I was young. Bacteriology and cytology are of recent origin. Plant physiology has been with us a child of slow growth, but it frequently has been the case that the strongest men have been slow in their development. Plant pathology from a crude and semi-popular beginning has become an exact science in whose study and practical application we have already surpassed other nations. When this society meets forty years hence, I shall not be present. Few of you will be present. But whatever of progress the speaker on that occasion may be able to report will be the result of a gradual development. It can hardly be expected that he will have to record any such radical and complete transformation as it has been my privilege to present to you this evening.

HARVARD UNIVERSITY.

THE CONSTITUENTS OF TARAXACUM ROOT.¹

By FREDERICK BELDING POWER and HENRY BROWNING, JR.

The root of the common dandelion (*Taraxacum officinale*, Wiggers) appears to have been employed medicinally for several centuries, and it still maintains a place in the more important national Pharmacopœias. It is therefore somewhat remarkable

¹ From *Trans. Chem. Soc.* 1912 (vol. 101) pp. 2411-2429.

that up to the present time so little of a definite nature should be known respecting its constituents, for, apart from the observed presence of inulin—which is common to the family of *Compositæ*—lævulin, and such ordinary constituents of plants as sugar, resin, and mucilage, no well-characterised compound has hitherto been isolated from this root.

Polex (*Arch. Pharm.*, 1839, 19, 50) has stated that on boiling the milky juice of taraxacum with water, filtering and concentrating the liquid, a crystalline substance was obtained which was sparingly soluble in cold water but readily so in boiling water, alcohol, or ether, and possessed an agreeably bitter, somewhat acrid taste. This substance was termed "taraxacin," but no analysis, melting point, or other characters were recorded which would serve for its identification. It was also noted by Polex (*loc. cit.*) that the resinous and albuminous material which separated on heating the milky juice to boiling, when extracted with alcohol, yielded a substance which crystallised in a white, cauliflower-like form.

Kromayer (*Arch. Pharm.*, 1861, 105, 6) examined the dried milky juice of the plant, for which he proposed the name "leontodonium." From the portion of this which was soluble in water he obtained some crystals mixed with amorphous material, but did not succeed in isolating the so-called "taraxacin." The portion of the dried milky juice which was insoluble in water yielded, on extraction with alcohol, "tasteless, spherical granules," which the author designated as "taraxacerin." An analysis (C=79.44; H=12.69 per cent.) was recorded of this substance, but no melting point, and to it the formula $C_{40}H_{80}O_5$ (or the simpler expression $C_8H_{16}O$) has since been assigned.

It is apparent from present knowledge that the so-called "taraxacin" and "taraxacerin" of the above-mentioned authors could not have been pure or homogeneous substances. The statements which have subsequently been recorded in the literature respecting the proportion of "taraxacin" in taraxacum root, with the assumption that it represents a distinct bitter principle, are therefore quite illusory.

L. E. Sayre has more recently contributed a number of papers on the subject of taraxacum (*Proc. Amer. Pharm. Assoc.*, 1893, p. 77; 1894, p. 241; 1895, p. 203; 1896, p. 160; 1897, p. 223; 1898, p. 341), but his investigations do not appear to have resulted in the isolation of any definite constituent of the root.

The question regarding the occurrence of mannitol in taraxacum root was investigated many years ago by T. and H. Smith (*Pharm. J.*, 1849, 8, 480), who conclusively proved that this compound does not pre-exist therein, but that it is formed when an extract of the root undergoes the so-called mucous or viscous fermentation. Its formation under these conditions would appear to permit of explanation by the fact that taraxacum root contains an abundance of inulin, which, on hydrolysis, is converted into lævulose, and the latter, by the special fermentative process referred to, becomes reduced to mannitol. The above observation has now also been confirmed by the present authors, inasmuch as no trace of mannitol could be isolated directly from the root employed for this research.

While the present investigation was in progress it has been recorded (*Brit. Med. J.*, May 25th, 1912, p. 1181) that the use of taraxacum in cases of cancer has been attended with remarkably beneficial results, and shortly afterwards (*ibid.*, July 13th, 1912, p. 97) attention was directed to the use of choline in the treatment of this disease. Additional interest is imparted to these two quite independent observations, especially when considered conjointly, by the fact that taraxacum root has now been found to contain choline. The various other well-defined compounds which have been isolated are summarized at the end of this paper.

EXPERIMENTAL.

The material employed for this investigation consisted of the best quality of English taraxacum root, which was collected in the autumn of 1911, and kindly supplied to us by Messrs. W. Ransom and Son, of Hitchin.

A small portion (25 grams) of the ground root was treated with Prollius' fluid, and the resulting product tested for an alkaloid with the usual reagents. The reactions obtained were so slight as to indicate the presence of not more than traces of an alkaloidal substance.

Another portion (20 grams) of the ground material was successively extracted in a Soxhlet apparatus with various solvents, and the resulting extracts dried in a water-oven until of constant weight:

Petroleum (b. p. 35–60°) extracted	0.28 gram = 1.40 per cent.
Ether extracted	0.06 gram = 0.30 per cent.
Chloroform extracted	0.05 gram = 0.25 per cent.
Ethyl acetate extracted	0.34 gram = 1.70 per cent.
Alcohol extracted	2.33 gram = 11.65 per cent.
Water extracted	10.20 gram = 51.00 per cent.

Total 13.26 grams = 66.3 per cent.

In order to ascertain whether an enzyme were present, 200 grams of the air-dried root were extracted with cold water, and to the clear, filtered liquid about twice its volume of alcohol was added. A slight precipitate was thus produced, which, when collected and dried in a vacuum over sulphuric acid, could be reduced to a brown powder. This product, which amounted to 0.85 gram, very slowly hydrolysed amygdalin, and thus possessed some enzymic activity.

For the purpose of a complete examination of the constituents of the root, 22.9 kilograms of the dried, ground material were extracted by continuous percolation with hot alcohol. After the removal of the greater portion of the alcohol, 7.3 kilograms of a viscid, dark-colored extract were obtained.

One kilogram of the alcoholic extract, representing about 3.14 kilograms of the root, was examined for sucrose by the following method: The extract was first mixed with water to separate the resin, which was incorporated with the larger portion subsequently obtained, and designated as (B). The filtered, aqueous liquid was then treated with an excess of milk of lime, again filtered, and the alkaline filtrate saturated with carbon dioxide. This liquid, after filtration, was evaporated under diminished pressure to the consistency of a syrup, and the latter treated with successive portions of alcohol until a product was finally obtained, which dissolved completely in alcohol of about 85 per cent. strength. The solution of this product, when decolorised with a little animal charcoal and kept for several months, deposited no crystalline substance, and there was therefore no indication of the presence of sucrose.

DISTILLATION OF THE EXTRACT WITH STEAM, SEPARATION OF AN ESSENTIAL OIL.

The entire remaining portion (6.3 kilograms) of the above-mentioned alcoholic extract of the root was mixed with water, and distilled in a current of steam. The distillate was extracted with

ether, the ethereal liquid dried, and the solvent removed, when a small amount of a dark yellow essential oil was obtained. This oil had a strong, persistent odor, and gave the color reaction for furfuraldehyde.

NON-VOLATILE CONSTITUENTS OF THE EXTRACT.

After the above-described operation there remained in the distillation flask a dark-colored aqueous liquid (*A*), together with a quantity of a soft, somewhat oily resin (*B*). The resinous material, the separation of which was attended with considerable difficulty, was finally washed thoroughly with warm water, and the washings added to the main portion of the aqueous liquid.

EXAMINATION OF THE AQUEOUS LIQUID (*A*).

The aqueous liquid, after concentration under diminished pressure, was extracted many times with ether. These ethereal liquids were united, the greater portion of the solvent removed, and the residue mixed with about an equal volume of light petroleum (b. p. 35—50°), when a red oil was deposited. On decanting and concentrating the supernatant liquid, and again treating it with light petroleum, further small quantities of red oil were obtained, which were added to the first portion. The mixture of ether and light petroleum was finally evaporated, the residue dissolved in ether, and the ethereal liquid shaken successively with aqueous ammonium carbonate, sodium carbonate, and sodium hydroxide. Each of these alkaline liquids was acidified, extracted with ether, and the solvent evaporated.

ISOLATION OF *p*-HYDROXYPHENYLACETIC ACID, $C_6H_4(OH).CH_2.CO_2H$.

The product obtained from the above-mentioned ammonium carbonate extract was a dark yellow oil. This was treated with hot water and a little animal charcoal, and the liquid filtered, when, on cooling, a gum-like mass separated, which gradually became crystalline. After recrystallisation from benzene containing a little ethyl acetate, a very small amount (about 0.05 gram) of an acidic substance was obtained, which separated in colorless needles, melting at 144—145°. The above-mentioned red oil, which was deposited by the addition of light petroleum to the concentrated ethereal liquid, was redissolved in ether, and extracted successively with

aqueous alkalis, as already described. The ammonium carbonate extract thus obtained, when acidified, yielded a gum-like product, which was esterified. The acid was then regenerated from the ester and crystallised several times from ethyl acetate, when it separated in flat needles melting at $144-146^{\circ}$, and amounted to about 0.4 gram. It was identical with the small portion (0.05 gram) of acid first obtained. By the subsequent extraction of both portions of the original ethereal extract with sodium carbonate and sodium hydroxide respectively, only small amounts of dark-colored, amorphous products were obtained, from which nothing definite could be isolated.

The above-described acid was dried at 105° and analysed:

0.0632 gave 0.1451 CO_2 and 0.0294 H_2O . $\text{C}=62.6$; $\text{H}=5.2$.

0.0818 " 0.1894 CO_2 " 0.0379 H_2O . $\text{C}=63.1$; $\text{H}=5.1$.

0.1009 neutralised 32.5 c.c. $N/50\text{-KOH}$. M.W. (monocarboxylic acid)=155.

$\text{C}_8\text{H}_8\text{O}_3$ requires $\text{C}=63.1$; $\text{H}=5.3$ per cent. M.W.=152.

A determination of the molecular weight of the acid by Barger's microscopic method was kindly made for us by Mr. A. J. Ewins, B.Sc., with the following result:

0.048 in 1.196 of absolute alcohol, using *a*-naphthol as the standard, was between 0.26 and 0.275 mol. Mean M.W.=150.

The acid was soluble in cold, and more readily in warm, water, as also in alcohol, ether, ethyl acetate, and acetone, but only slightly so in benzene or the higher boiling fractions of petroleum. Its dilute aqueous solution gave no perceptible coloration with ferric chloride. With Million's reagent it yielded the deep red color characteristic of the aromatic monohydroxy-acids (*Ber.*, 1879, 12, 1452); and a trace of the substance, when heated with soda-lime, gave a distinct phenolic odor.

A consideration of the composition and characters of the above-described substance indicated it to be *p*-hydroxyphenylacetic acid, which has not previously been observed to occur as such in the vegetable kingdom. It was obtained by A. G. Perkin and Newbury (*Trans.*, 1899, 75, 834) by the action of potassium hydroxide on genistein, and Ewins and Laidlaw (*J. Physiol.*, 1910, 41, 78) have

shown that when *p*-hydroxyphenylethylamine is administered by the mouth to an animal, it is transformed to a large extent into *p*-hydroxyphenylacetic acid, which may subsequently be extracted from the urine.

In order completely to establish the identity of the substance above described with *p*-hydroxyphenylacetic acid, it was deemed desirable to compare it with the synthetic acid, especially as it had been stated by Salkowski (*Ber.*, 1879, 12, 1438), who first effected its synthesis, that its aqueous solution gives with ferric chloride a slight greyish-violet coloration, which immediately changes to a dirty greyish-green. It was, moreover, thought possible that the coloration given by the synthetic product might be due to a slight contamination with the corresponding ortho-compound, which is known to produce a violet color with ferric chloride. Baumann (*Ber.*, 1880, 13, 279), who obtained *p*-hydroxyphenylacetic acid from human urine, has, however, also noted that its aqueous solution gives with ferric chloride a slight violet coloration.

A quantity of the synthetic acid was accordingly prepared from phenylacetic acid, the latter having first been nitrated according to the method of Maxwell (*Ber.*, 1879, 12, 1765). After very prolonged fractional crystallisation from warm water, a product was obtained which melted at 152°, the pure *p*-nitrophenylacetic acid having been observed by Maxwell (*loc. cit.*) to melt at 150°, and by Bedson (*Trans.*, 1880, 37, 91) at 150–151°. This nitro-acid was reduced by tin and hydrochloric acid, and then, by means of the diazo-compound, converted into the corresponding hydroxy-acid. The acid thus prepared was found to have the same melting point as that obtained from taraxacum root, and when the two products were mixed no depression of the melting point ensued. The reaction with Millon's reagent was precisely the same as that previously mentioned. On comparing the behaviour of the natural and the synthetic acid towards ferric chloride, it was observed in both cases that if a fairly concentrated solution of the acid were employed a faint and exceedingly fugitive violet coloration was produced, rapidly changing to greenish-brown, thus confirming the observations of Salkowski and of Baumann (*loc. cit.*)

The above results thus completely established the identity of the acid from taraxacum root with *p*-hydroxyphenylacetic acid.

After the extraction of the original aqueous liquid with ether, as above described, it was shaken with eighteen successive portions

of warm amyl alcohol. These amyl-alcoholic liquids were united, washed with water, concentrated under diminished pressure to the consistency of a syrup, and the last traces of amyl alcohol removed by passing steam through the liquid. The syrupy product was then further concentrated under diminished pressure, afterwards on a water-bath, and finally dried as completely as possible in a vacuum desiccator. There was thus obtained a quantity (42.5 grams) of a dark brown, viscous mass, which possessed a strongly bitter taste, and in aqueous solution gave a dark green color with ferric chloride.

Twelve grams of the above-mentioned product were heated for two hours with 5 per cent. sulphuric acid in aqueous alcohol. On subsequently distilling the mixture in a current of steam, a very small amount of a yellow oil was obtained, which gave the color reaction of furfuraldehyde. The aqueous acid liquid was then extracted many times with ether, after which the sulphuric acid was removed by barium hydroxide, the excess of the latter by carbon dioxide, and the filtered liquid concentrated. From this syrupy product a small amount of an osazone (m. p. 210—211°) was prepared, thus indicating that some glucosidic material was contained in the amylalcoholic extract. The above-mentioned ethereal extract of the aqueous acid liquid was thoroughly extracted with aqueous ammonium carbonate, after which the ethereal liquid was dried and evaporated, but only a trace of yellow, amorphous material remained. On acidifying the ammonium carbonate extract, however, extracting many times with ether, and evaporating the solvent, a small amount of a crystalline substance was deposited. After recrystallisation from ethyl acetate this was obtained in thin, flat needles, melting at 146°, and was identical with the *p*-hydroxyphenylacetic acid, $C_8H_8O_3$, previously described. (Found, C=62.5; H=5.4. Calc., C=63.1; H=5.3 per cent.) The amount thus obtained was only 0.09 gram.

Another portion (27 grams) of the above-mentioned amyl-alcoholic extract was heated for a few minutes with a 10 per cent. solution of potassium hydroxide; the mixture then rapidly cooled and acidified, when a quantity of resinous material separated. This was collected, mixed with purified sawdust, and the dried mixture thoroughly extracted with ether. The aqueous acid liquid from which the resin had been removed was likewise extracted many times with ether, after which the two ethereal liquids were united

and extracted with aqueous ammonium carbonate. On subsequently evaporating the ether there remained a slight residue, from which a crystalline substance melting at $233-235^{\circ}$ was obtained. This substance was very soluble in chloroform, almost insoluble in ethyl acetate, and gave no coloration with ferric chloride, but the amount obtained (0.04 gram) was too small to permit of its further examination. The ammonium carbonate extract, when acidified and extracted with ether, yielded a small amount of a semi-crystalline product, which was readily soluble in warm water, and its solution gave with ferric chloride a deep green color. The whole of this product was heated with chloroform containing a trace of ethyl acetate, when a small amount of a brown substance remained undissolved. The latter was crystallised from very dilute alcohol, when 0.07 gram of an acid was obtained, which melted and decomposed at 214° , and gave a deep green color with ferric chloride. This substance was evidently 3:4-dihydroxycinnamic acid, since no depression of the melting point ensued when mixed with a pure specimen of the respective acid, and it was subsequently obtained in an amount which permitted of its complete identification, as will be further noted. The portion of the above-mentioned product which had dissolved in the mixture of chloroform and ethyl acetate formed, after the evaporation of the solvent, a viscid mass, which was repeatedly extracted with boiling benzene. From the latter liquid some crystals were deposited, which, after several crystallisations from benzene containing a little alcohol, separated in flat needles melting at $145-146^{\circ}$. This substance amounted to 0.25 gram, and was identified as *p*-hydroxyphenylacetic acid. (Found, C = 62.6; H = 5.4. Calc., C = 63.1; H = 5.3 per cent.)

After the extraction of the original aqueous liquid with amyl alcohol, as above described, the last traces of the latter were removed by a current of steam. The liquid was then treated with a solution of basic lead acetate until no further precipitate was produced, the precipitate collected and thoroughly washed with water, the washings being added to the main portion of the filtered liquid.

ISOLATION OF 3:4-DIHYDROXYCINNAMIC ACID,
 $C_6H_3(OH)_2 \cdot CH:CH \cdot CO_2H$.

A portion of the above-mentioned basic lead acetate precipitate, representing 2 kilograms of the original alcoholic extract, was suspended in water, decomposed by hydrogen sulphide, and the mixture

filtered. The filtered liquid was then concentrated under diminished pressure to the consistency of a thin syrup. It gave a dark brown coloration with ferric chloride, but no precipitate with gelatin, thus indicating the absence of tannin, and it also gave no reaction with potassium-mercuric iodide. As nothing separated from the liquid on keeping, it was heated to boiling, neutralised with potassium hydroxide, and sufficient of a concentrated solution of the latter added to represent about 10 per cent. of the mixture, after which it was boiled for about five minutes. The liquid was then poured into dilute sulphuric acid, and, after cooling, the mixture was extracted many times with ether, the combined ethereal liquids being subsequently extracted with aqueous ammonium carbonate and sodium hydroxide. Nothing of interest was removed by the last-mentioned alkali, and on finally evaporating the ether only a trace of amorphous material remained. The ammonium carbonate extract, however, after acidification and extraction with ether, yielded a product which gave with ferric chloride a dark green color. From this product, after several crystallisations from hot water containing a little alcohol, a small amount (about 0.2 gram) of an acid was obtained, which melted and decomposed at $214-216^{\circ}$ with evolution of gas. It was dried at 110° , and analysed:

0.0643 gave 0.1405 CO_2 and 0.0265 H_2O . $\text{C} = 59.6$; $\text{H} = 4.6$.

$\text{C}_9\text{H}_8\text{O}_4$ requires $\text{C} = 60.0$; $\text{H} = 4.4$ per cent.

The above-described substance was thus definitely identified as 3:4-dihydroxycinnamic acid, a smaller amount of which had previously been obtained from the amyl-alcoholic extract of the original aqueous liquid.

The filtrate from the precipitate produced by basic lead acetate was treated with hydrogen sulphide for the removal of the excess of lead, again filtered, and concentrated under diminished pressure to the consistency of a syrup. It evidently contained an abundance of sugar, since it readily yielded *d*-phenylglucosazone, melting at $204-206^{\circ}$. A portion of the syrup was acetylated, but as nothing crystalline separated from the product, even after long keeping, it was finally hydrolysed. The regenerated sugar was then found to be strongly laevorotatory, thus indicating that it must have consisted, to a large extent at least, of laevulose. Another portion of the syrup was heated for about two hours with 5 per cent. sulphuric

acid, but, with the exception of traces of furfuraldehyde, it yielded nothing definite by this treatment. A further portion of the syrup was mixed with purified sawdust, and the dried mixture extracted successively in a Soxhlet apparatus with ether, chloroform, and ethyl acetate, but only small amounts of sugary material were thus removed.

The original syrupy liquid, when heated with an alkali hydroxide developed a strongly basic, ammoniacal odour, and it gave an appreciable precipitate with a solution of iodine in potassium iodide.

ISOLATION OF CHOLINE, $C_5H_{15}O_2N$.

The main portion of the above-mentioned syrupy aqueous liquid was thoroughly extracted with alcohol, the resulting liquid evaporated, and the residue from the latter repeatedly treated with alcohol, in the same manner, until a product was finally obtained which was soluble in nearly absolute alcohol. By this means a large proportion of the sugar was eliminated, together with any other material which was sparingly soluble in alcohol. To the alcoholic solution thus obtained a saturated alcoholic solution of mercuric chloride was added, and the mixture kept in a closed vessel for a week. The precipitate which had then formed was collected, washed with a little alcohol, dissolved as completely as possible in warm water, and the solution filtered. The mercury was subsequently removed from this solution by hydrogen sulphide, the liquid again filtered, neutralised with sodium carbonate, then slightly acidified with hydrochloric acid, and finally evaporated to dryness, for the most part in a vacuum desiccator. The dry residue was treated with absolute alcohol, the filtered liquid evaporated, and the residue repeatedly so treated until free from inorganic salt. A relatively small amount of a nearly colorless product was thus obtained, which deliquesced on exposure to the air, and the aqueous solution of which was precipitated by the usual alkaloidal reagents, as also by gold chloride. It possessed, in fact, all the recognised properties of choline chloride. A small portion of the substance was dissolved in a little water, and precipitated by a solution of auric chloride, the pale yellow precipitate being collected, washed with a little water, and dried at $100-105^\circ$:

0.0332 gave on ignition 0.017 Au. Au = 44.3.

$C_5H_{14}ONCl, AuCl_3$ requires Au = 44.5 per cent.

Another portion of the substance was dissolved in absolute alcohol, and a solution of platinic chloride added. The resulting precipitate was collected, washed with a little alcohol, and dissolved in a small amount of water. After keeping for some time, reddish-brown plates were deposited, which melted and decomposed at 250—254°:

0.0460, when heated at 110°, lost 0.0010 H₂O. H₂O = 2.2.

0.0450² gave on ignition 0.0143 Pt. Pt = 31.8.

0.0844² gave on ignition 0.0269 Pt. Pt = 31.9.

(C₅H₁₄ONCl)₂PtCl₄·H₂O requires H₂O = 2.8 per cent.

(C₅H₁₄ONCl)₂PtCl₄ requires Pt = 31.7 per cent.

The occurrence of choline as a constituent of taraxacum root has thus been established.

EXAMINATION OF THE RESIN (B).

The crude resinous material which had been separated from the aqueous liquid (A), as previously described, was dissolved in alcohol, mixed with purified sawdust, and the thoroughly dried mixture extracted successively in a large Soxhlet apparatus with various solvents. The weights of the products, as determined by drying small, aliquot portions in a water-oven, were as follows:

Petroleum (b. p. 35—50°)	extracted	329.6 grams.
Ether	extracted	19.6 grams.
Chloroform	extracted	10.0 grams.
Ethyl acetate	extracted	10.5 grams.
Alcohol	extracted	40.0 grams.

Total..... 409.7 grams.

As the above amount of resin was obtained from 7.3 kilograms of the original alcoholic extract, it is equivalent to about 1.8 per cent. of resin in the air-dried root.

PETROLEUM EXTRACT OF THE RESIN.

IDENTIFICATION OF THE FREE FATTY ACIDS.

After the removal of the solvent from the petroleum extract the residue was dissolved in ether, and the ethereal liquid shaken successively with aqueous ammonium carbonate, sodium carbonate.

² Anhydrous substance.

and sodium hydroxide. The clear, alkaline liquids yielded, on acidification, only traces of fatty material, but both the sodium carbonate and sodium hydroxide produced, to some extent, emulsions, which were separated, and the ether removed, when a solid product was obtained. This consisted of the sodium salt of fatty acids. It was suspended in dilute sulphuric acid and warmed with chloroform, which removed about 15 grams of fatty acids. The latter were converted into their methyl esters, which were distilled three times under diminished pressure, and three fractions collected. The first two fractions consisted of methyl palmitate, melting at $27-28^{\circ}$. (Found, C = 75.0; H = 12.7. Calc., C = 75.5; H = 12.6 per cent.) The third fraction, which distilled at $206-208^{\circ}/15$ mm., was liquid and unsaturated:

0.2933 absorbed 0.3164 iodine. Iodine value = 107.9.

For the further examination of this fraction it was converted into a lead salt, and the latter treated with ether. The portion insoluble in ether, when decomposed by hydrochloric acid, yielded 1.5 grams of a solid acid, which distilled between 230° and $235^{\circ}/27$ mm., and, after crystallisation, melted at $60-61^{\circ}$. It was identified as palmitic acid. (Found, C = 75.0; H = 12.8. Calc., C = 75.0; H = 12.5 per cent.) The portion of lead salt which was soluble in ether, when decomposed by hydrochloric acid, yielded 7 grams of liquid acids, which distilled between 220° and $235^{\circ}/12$ mm.:

0.1134 gave 0.3200 CO_2 and 0.1188 H_2O . C = 76.9; H = 11.6.

0.3898 absorbed 0.6111 iodine. Iodine value = 156.8.

These results indicate that the liquid acids consisted essentially of a mixture of oleic and linolic acids, the latter predominating.

The ethereal liquid which had been shaken with aqueous alkalis, as above described, was subsequently evaporated, and the residue heated with an alcoholic solution of potassium hydroxide. The alcohol was then evaporated, water added, and the alkaline mixture extracted with ether, when a quantity of unsaponifiable material was removed, which will subsequently be described.

IDENTIFICATION OF THE COMBINED FATTY ACIDS.

ISOLATION OF MELISSIC ACID, $\text{C}_{30}\text{H}_{60}\text{O}_2$.

During the above-mentioned extraction of the alkaline liquid with ether, a slight emulsion was formed. This was thoroughly washed with ether, then freed from the latter, and brought on a

filter. A small amount of substance was thus collected, which proved to be the potassium salt of a fatty acid. The acid was liberated, dissolved in chloroform, and crystallised from ethyl acetate, when it melted at $87.5-88.5^{\circ}$, and amounted to 0.1 gram:

0.0821 gave 0.2399 CO_2 and 0.0983 H_2O . $\text{C} = 79.7$; $\text{H} = 13.3$.

$\text{C}_{30}\text{H}_{60}\text{O}_2$ requires $\text{C} = 79.7$; $\text{H} = 13.3$ per cent.

The small remaining portion of the acid was converted into its methyl ester, which, after crystallisation from alcohol, melted at $72-73^{\circ}$.

The above-described acid was thus identified as melissic acid, which, so far as is known to us, has never previously been obtained directly from a plant.

The aqueous alkaline liquid from which the unsaponifiable material had been removed by extraction with ether, as above described, was acidified and again extracted with ether. This ethereal liquid was dried, the solvent removed, and the residual fatty acids converted into their methyl esters. The latter, when distilled under diminished pressure, passed over between 180° and $270^{\circ}/9$ mm., and amounted to about 55 grams. They were optically inactive. The esters were then hydrolysed, and the resulting product, which consisted of a mixture of saturated and unsaturated acids, was separated into liquid and solid portions by means of the lead salts.

The Liquid Acids.—These acids, when distilled under diminished pressure, passed over between 215° and $265^{\circ}/18$ mm., and amounted to about 40 grams. An analysis and a determination of the iodine value gave the following results:

0.1343 gave 0.3800 CO_2 and 0.1393 H_2O . $\text{C} = 77.2$; $\text{H} = 11.5$.

0.3100 absorbed 0.4448 iodine. Iodine value = 143.5.

$\text{C}_{18}\text{H}_{34}\text{O}_2$ requires $\text{C} = 76.6$; $\text{H} = 12.1$ per cent. Iodine value = 90.1.

$\text{C}_{18}\text{H}_{32}\text{O}_2$ " $\text{C} = 77.1$; $\text{H} = 11.4$ " " " " = 181.4.

$\text{C}_{18}\text{H}_{30}\text{O}_2$ " $\text{C} = 77.7$; $\text{H} = 10.8$ " " " " = 274.1.

The above results would indicate that the liquid acids consisted chiefly of a mixture of oleic and linolic acids, with possibly a little linolenic acid.

The Solid Acids.—These acids, which amounted to 10 grams, were fractionally crystallised from ethyl acetate. The least soluble

fraction so obtained separated in small needles, which melted quite constantly at 82—84°:

0.0673 gave 0.1946 CO₂ and 0.0820 H₂O. C = 78.8; H = 13.5.

C₂₇H₅₄O₂ requires C = 79.0; H = 13.2 per cent.

This acid was thus identified as cerotic acid, although the melting point was somewhat higher than that usually assigned to it.

The next two fractions, of lower melting point (75—77°), also appeared to consist essentially of cerotic acid, since they gave on analysis the following figures: C = 78.5; H = 13.2 per cent.

The most readily soluble fractions, which melted at 56—58°, were distilled under diminished pressure, when practically the whole passed over between 205° and 207°/12 mm. After one crystallisation of the product it melted at 60—61°, and was identified as palmitic acid. (Found, C = 75.0; H = 12.7. Calc., C = 75.0; H = 12.5 per cent.)

UNSAAPONIFIABLE CONSTITUENTS OF THE PETROLEUM EXTRACT.

The ethereal liquid, obtained by extracting the hydrolysed petroleum extract of the resin with ether, as above described, was dried, and the solvent removed, when 125 grains of a yellow solid were obtained. An attempt was first made to separate the constituents of this material by direct fractional crystallisation, but, as this was unsuccessful, the various fractions were separately acetylated, and the resulting products subjected to prolonged fractional crystallisation. The solvents employed for this purpose were ethyl acetate and a mixture of the latter with alcohol.

ISOLATION OF A NEW MONOHYDRIC ALCOHOL, TARAXASTEROL, C₂₉H₄₇·OH.

After many crystallisations of the above-mentioned acetylated products, a small fraction (5.2 grams) was obtained, which separated in handsome, colourless, hexagonal plates, melting at 251—252°, and this melting point was not changed by further crystallisation. A portion of this acetyl derivative was hydrolysed by boiling it for three or four hours with an alcoholic solution of potassium hydroxide, after which the alcohol was for the most part removed, water added, and the resulting solid collected. On crystal-

lisation from alcohol, it separated in long, colorless needles, melting at 221—222°:

0.1999, when heated at 125°, lost 0.0198 H₂O. H₂O = 9.9.
 0.0848³ gave 0.2625 CO₂ and 0.0902 H₂O. C = 84.4; H = 11.8.
 0.0737³ “ 0.2284 CO₂ “ 0.0772 H₂O. C = 84.5; H = 11.6.
 C₂₀H₄₈O, 2½H₂O requires H₂O = 9.8 per cent.
 C₂₉H₄₈O requires C = 84.5; H = 11.6 per cent.

It is evident from these results that the above-described compound possesses the formula C₂₉H₄₈O, and, being a new alcohol, having properties similar to those of the phytosterols, it is proposed to designate it *taraxasterol*, with reference to the source from which it has been obtained.

A determination of its optical rotatory power gave the following result:

0.4343,³ made up to 20 c.c. with chloroform, gave α_D +4° 11' in a 2-dcm. tube, whence [α]_D +96.3°.

Taraxasterol is homologous with two monohydric alcohols previously isolated in these laboratories from the rhizome of *Apocynum androsaemifolium*, namely androsterol, C₃₀H₅₀O, and homo-androsterol, C₂₇H₄₄O (Trans., 1909, 95, 739), and it gives a color reaction similar to that yielded by the last-mentioned compounds; thus, if a small amount of the substance be dissolved in chloroform with a little acetic anhydride, and a few drops of concentrated sulphuric acid subsequently added, a pink color is produced, which slowly changes to a dark magenta with a green fluorescence, and this color persists for several hours. The above-mentioned alcohols, together with a homologue of taraxasterol to be subsequently described, C₂₅H₄₀O, constitute four members of a group which is represented by the general formula C_nH_{2n-10}O.

Acetyltaraxasterol, C₂₉H₄₇O.CO.CH₃.—This compound (m. p. 251—252°), the preparation and characters of which have already been described, was dried at 120° and analysed:

0.0866 gave 0.2602 CO₂ and 0.0854 H₂O. C = 81.9; H = 10.9.
 0.0824 “ 0.2472 CO₂ “ 0.0810 H₂O. C = 81.8; H = 10.9.
 C₃₁H₅₀O₂ requires C = 81.9; H = 11.0 per cent.

³ Dried at 120°.

A determination of its optical rotatory power gave the following result:

0.2046,⁴ made up to 20 c.c. with chloroform, gave $\alpha_D +2^\circ 30'$ in a 2-dcm. tube, whence $[\alpha]_D +122.2^\circ$.

Monobromoacetyltaraxasterol, $C_{29}H_{46}BrO.CO.CH_3$.—Half a gram of the above-described acetyl derivative was dissolved in chloroform, and to the cold solution a slight excess of a solution of bromine in the same solvent was slowly added. The product was crystallised from ethyl acetate, when it separated in small, colorless needles, melting at $233-234^\circ$:

0.1204 gave 0.0421 AgBr. Br. = 14.9.

$C_{31}H_{40}O_2Br$ requires Br = 15.0 per cent.

Benzoyltaraxasterol, $C_{29}H_{47}O.CO.C_6H_5$.—This derivative was prepared by heating the respective alcohol for a short time with benzoyl chloride and a few drops of pyridine. The product, after several crystallisations from a mixture of alcohol and chloroform, separated in glistening leaflets melting at 232° :

0.0810⁵ gave 0.2471 CO_2 and 0.0728 H_2O . C = 83.2; H = 10.0.

$C_{36}H_{52}O_2$ requires C = 83.7; H = 10.1 per cent.

Other well-crystalised fractions obtained from the original acetylated product above described possessed the following characters:

I. M. p. $216-222^\circ$; $[\alpha]_D +68.1^\circ$; C = 81.7; H = 10.9 per cent.

II. M. p. $225-227^\circ$; $[\alpha]_D +62.2^\circ$; C = 81.5; H = 11.1 " "

III. M. p. $225-235^\circ$; $[\alpha]_D +77.8^\circ$; C = 81.6; H = 11.3 " "

The composition and characters of these fractions indicated them to contain a substance analogous to taraxasterol, but having a lower melting point and a lower optical rotation. The mother-liquors from these fractions were evaporated, and the residues brominated. By the fractional crystallisation of the product, a further amount of the above-described monobromoacetyltaraxasterol was obtained.

Fractions of the acetylated product melting lower than those above mentioned could only be crystallised with difficulty. The

⁴ Dried at 120° .

⁵ Dried at 120° .

mother liquors from these fractions were evaporated to dryness, the residues hydrolysed, and then treated with phthalic anhydride, both in the dry state and with the admixture of a little pyridine or xylene. No acid phthalic ester could, however, be isolated by this treatment.

ISOLATION OF A NEW MONOHYDRIC ALCOHOL, HOMOTARAXASTEROL,
 $C_{25}H_{39}OH$.

The above-mentioned difficultly crystallisable fractions of acetylated material were united, hydrolysed, and the product distilled under diminished pressure, when practically the whole passed over between 335° and $340^{\circ}/25$ mm. The distillate, which was contaminated with some oily material, was purified by dissolving it in petroleum of high boiling point, and treatment with animal charcoal. A product was thus obtained, which, after several crystallisations from dilute alcohol, separated in small needles melting constantly at $163-164^{\circ}$. The substance did not undergo any appreciable loss in weight on drying at 120° , and the total amount obtained was 0.45 gram:

0.0741 gave 0.2280 CO_2 and 0.0770 H_2O . $C = 83.9$; $H = 11.5$.
 $C_{25}H_{40}O$ requires $C = 84.3$; $H = 11.2$ per cent.

The composition of this substance clearly indicated it to be a lower homologue of the above-described taraxasterol, and it yielded precisely the same color reaction as the latter. Being also a new compound it is proposed to designate it *homotaraxasterol*.

A determination of its optical rotary power gave the following result:

0.0989, made up to 20 c.c. with chloroform, gave $\alpha_D + 0^{\circ} 15'$ in a 2-dcm. tube, whence $[\alpha]_D + 25.3^{\circ}$.

Acetylhomotaraxasterol, $C_{25}H_{39}O.CO.CH_3$.—This compound was prepared by heating the respective alcohol with acetic anhydride. It separated from a mixture of ethyl acetate and alcohol in small, colorless needles, melting at $219-220^{\circ}$:

0.0654 gave 0.1943 CO_2 and 0.0645 H_2O . $C = 81.0$; $H = 10.9$.
 $C_{27}H_{42}O_2$ requires $C = 81.4$; $H = 10.5$ per cent.

0.0888, made up to 20 c.c. with chloroform, gave $\alpha_D + 0^{\circ} 15'$ in a 2-dcm. tube, when $[\alpha]_D + 28.1^{\circ}$.

A very small portion of homotaraxasterol was converted into its *benzoyl* derivative, which separated from a mixture of chloroform and alcohol in small, flat needles, melting at 202° . The amount of this compound was not sufficient for analysis.

ETHER EXTRACT OF THE RESIN.

This extract was considerably concentrated in volume and kept for some time, when a small amount of a sparingly soluble grey substance was deposited. This was collected, and the clear, ethereal liquid then extracted successively with aqueous ammonium carbonate and sodium carbonate, which, however, removed only traces of brown, amorphous material. The ethereal liquid was finally extracted with aqueous potassium hydroxide, and the alkaline liquid acidified and extracted with ether, which removed some amorphous material, and at the same time an emulsion was formed. This was separated, washed with a little ether, and the latter removed by a current of air, when, on filtration, a further small amount of the above-mentioned grey substance was obtained. The ethereal liquid which had been extracted with alkalis when dried and evaporated, also yielded a little of the same sparingly soluble grey substance.

ISOLATION OF CLUYTIANOL, $C_{20}H_{40}O(OH)_4$.

The above-described grey substance was first subjected to prolonged extraction with absolute alcohol in a Soxhlet apparatus. During this operation it was partly deposited in a nearly white condition, and, on finally concentrating the alcoholic liquid, practically all the substance separated. The material thus obtained amounted to 4.1 grams. It was subsequently heated with acetic anhydride, and the resulting product fractionally crystallised many times from alcohol, when an acetyl derivative was obtained, which separated in colorless, flat needles, melting at 161° .

A portion of the acetyl derivative was hydrolysed by boiling with an alcoholic solution of potassium hydroxide. The product, after crystallisation from dilute pyridine, separated in minute, colorless crystals, melting and decomposing at 297° :

0.0826 gave 0.2197 CO_2 and 0.0790 H_2O . $C = 72.5$; $H = 10.6$.

$C_{20}H_{50}O_8$ requires $C = 72.8$; $H = 10.5$ per cent.

Although this substance agrees in its empirical composition with ipuranol, $C_{29}H_{47}O_2(OH)_3$, a trihydric alcohol which has been obtained in these laboratories from many sources, and also yields the same colour reaction as ipuranol, the analysis and characters of its derivatives proved it to be identical with a new tetrahydric alcohol, $C_{29}H_{46}O(OH)_4$, recently isolated by Tutin and Clewer from the South African plant *Cluytia similis*, Muell. Arg., and designated by them cluytianol (*Trans. Chem. Soc.*, vol. 101, p. 2230).

Tetra-acetylcluytianol, $C_{29}H_{46}O_5(CO.CH_3)_4$.—This compound (m. p. 161°) was prepared as above described:

0.0820 gave 0.2064 CO_2 and 0.0673 H_2O . $C = 68.6$; $H = 9.1$.

Its molecular weight was determined by Mr. H. W. B. Clewer:

0.4326, in 26.45 of benzene, gave $\Delta t = -0.12^\circ$. M.W. = 668.

$C_{37}H_{58}O_9$ requires $C = 68.7$; $H = 9.0$ per cent. M.W. = 646.

A determination of its optical rotatory power gave the following result:

0.1976, made up to 20 c.c. with ethyl acetate, gave $\alpha_D = -0^\circ 24'$ in a 2-dcm tube, when $[\alpha]_D = -20.2^\circ$.

Tetrabenzoylcluytianol, $C_{29}H_{46}O_5(CO.C_6H_5)_4$.—A little of this compound was prepared by treating the respective alcohol with benzoyl chloride in the presence of pyridine. The product, after repeated crystallisation from a mixture of chloroform and alcohol, separated in small, colorless needles, melting at 196° :

0.0620 gave 0.1733 CO_2 and 0.0443 H_2O . $C = 76.2$; $H = 7.9$.

$C_{57}H_{66}O_9$ requires $C = 76.5$; $H = 7.4$ per cent.

CHLOROFORM, ETHYL ACETATE, AND ALCOHOL EXTRACTS OF THE RESIN.

These extracts were dark brown, amorphous products, and amounted to 10, 10.5, and 40 grams respectively. They were separately examined, but nothing definite could be isolated from them. The ethyl acetate and alcohol extracts were therefore heated with dilute sulphuric acid in aqueous alcohol, and the mixture distilled in a current of steam. The distillate contained traces of an oily substance, which gave the color reaction of furfuraldehyde, but no sugar appeared to be produced, and the extracts were evidently not glucosidic.

SUMMARY AND CONCLUSIONS.

The material employed for this investigation consisted of the air-dried, fresh roots of taraxacum (*Taraxacum officinale*, Wiggers), collected in the autumn from plants grown in England.

The roots were found to contain a very small amount of an enzyme, which slowly hydrolysed amygdalin.

An alcoholic extract of the root, when distilled in a current of steam, yielded a small amount of a yellow essential oil. From the portion of the extract which was soluble in water, the following substances were isolated: (i) *p*-hydroxyphenylacetic acid, $C_8H_8O_3$ (m. p. 144–146°); (ii) 3:4-dihydroxycinnamic acid, $C_9H_8O_4$ (m. p. 214–216°); (iii) a small amount of choline, $C_5H_{15}O_2N$, which was identified by its gold and platinum compounds. The aqueous liquid contained, furthermore, a considerable quantity of a laevorotatory sugar, which appeared to consist chiefly, if not entirely, of laevulose, and yielded an osazone, melting at 204–206°.

The portion of the alcoholic extract which was insoluble in water consisted of a soft, oily resin, which amounted to 1.8 per cent. of the weight of the root. From this material the following compounds were isolated: (i) a new monohydric alcohol, *taraxasterol*, $C_{29}H_{47}.OH$ (m. p. 221–222°; $[\alpha]_D +96.3^\circ$), which yielded an *acetyl* derivative (m. p. 251–252°; $[\alpha]_D +122.2^\circ$), a *monobromoacetyl* derivative (m. p. 233–234°), and a *benzoyl* derivative (m. p. 232°); (ii) a new monohydric alcohol, *homotaraxasterol*, $C_{25}H_{39}.OH$ (m. p. 163–164°; $[\alpha]_D +25.3^\circ$), which yielded an *acetyl* derivative (m. p. 219–220° $[\alpha]_D +28.1^\circ$), and a *benzoyl* derivative (m. p. 202°). The above-mentioned alcohols, together with two previously isolated compounds, androsterol, $C_{30}H_{49}.OH$, and homoandrosterol, $C_{27}H_{43}.OH$ (*Trans.*, 1909, **95**, 739), constitute an homologous group, which is represented by the general formula $C_nH_{2n-10}O$; (iii) Cluytanol, $C_{29}H_{46}O(OH)_4$, melting at 297° (*Trans.*, 1912, p. 2230), from which the tetra-acetyl and tetrabenzoyl derivatives were prepared; (iv) palmitic, cerotic, and melissic acids, together with a mixture of unsaturated acids, consisting chiefly of oleic and linolic acids, with, apparently, a little linolenic acid.

The bitter taste of taraxacum, which has hitherto been ascribed to the so-called "taraxacin," appears to be due chiefly to dark-colored, amorphous material, and not to any distinct principle. It was found, for example, that the portion of an alcoholic extract

of the root which is soluble in water, when repeatedly extracted with warm amyl alcohol, yielded a viscous product, which possessed an intensely bitter taste.

A consideration of the results of the present investigation renders it evident that the products which many years ago received the designations of "taraxacin" and "taraxacerin" were not only indefinite in character, but must have consisted of very complex mixtures. It is therefore desirable that these names should no longer be retained in the literature.

THE WELLCOME CHEMICAL RESEARCH LABORATORIES,
LONDON, E. C.

ABSTRACT FROM THE REPORT OF THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION.

BY JOHN K. THUM, PH.G., Philadelphia, Pa.

In part II of the annual report of the Connecticut Agricultural Experiment Station an interesting account is given of the work done for the year 1912 in connection with food and drug products.

"This station is required by law to make examinations of food and drug products, to publish its findings, and to report to the dairy and food commissioner all cases of adulteration or misbranding which are discovered."

Among the food products investigated we might mention the following: canned goods, dried fruits, gluten and special foods, honey, (which is chiefly adulterated with cane sugar), commercial glucose and invert sugar, rice, and sausage.

Drug products examined were acetic acid, aconite, glycerine, herion, magnesium carbonate, solution of magnesium citrate, paregoric, sodium salicylate, precipitated sulphur, and turpentine.

It was also interesting to note that some attention was given by the Station to exposing some proprietary medicines that are advertised and sold to the public. The statement is made, and it is well-known among pharmacists or should be, that even when the claimed ingredients are present in a proprietary remedy, as a rule the purchaser pays an exorbitant price for it.

The work of this Station in its effort to put the proprietary or "patent medicine" evil in its proper light before the public is in line with the good work done by the Council on Pharmacy and Chemistry of the American Medical Association. And its work,

backed by the power and force of a State, should be of great value in informing and educating the people to the evil effects of nostrum medication. The leaven is working and it is only a question of time when work of this sort will be reënforced with coöperation by the daily newspapers.

For obvious reasons the newspapers are silent on these matters now. But they will, in due course, learn that the advocacy of measures designed for the public welfare must eventually rebound to *their* welfare and credit.

Publicity of the sort that only the daily newspaper can give is needed before the great mass of the people is reached on this vital question of public health.

Of the score or more of remedies examined we give brief abstracts of the following:

Schenk's Pulmonic Syrup.—"The 70-year-old Standard Remedy for Consumption, Coughs, Colds, Diseases of the Lungs and Respiratory Organs." This remarkable remedy for consumption, upon analysis, was shown to be a wintergreen-flavored mixture of saccharine syrups, 96.4 per cent. of the solids consisting of sugars.

The following is a summary of the analysis:

Specific gravity at 15.5° C.....	1.3861
Alcohol	none
Glycerine	none
Solids	75.59
Sucrose	34.49
Invert sugar	38.40
Ash	0.08
Oil of wintergreen	present
Alkaloids	none

Syrup of Figs.—This proprietary medicine has been on the market for a number of years. Formerly it was sold under the name Syrup of Figs, recently though many of the labels note the presence of Elixir of Senna, which is generally the real laxative. The reason for this change is apparent from the following extract from the opinion of the U. S. Court in the case, *Worden v. California Fig Syrup Co.*, 187 U. S., 516, 536:

"The argument for complainant is that, because fig juice or syrup has no laxative property, everybody ought to understand that when the term is used to designate a laxative medicine it must have only a fanciful meaning. But the fact is admitted that the public believe

that fig juice or syrup has laxative medicinal properties. It is to them that the complainant seeks to sell its preparations, and it is with respect to their knowledge and impression that the character, whether descriptive or fanciful, of the term used, is to be determined." Of the 13 samples analyzed, 6 were sold as compound fig syrup, 5 as compound fig and senna syrup, and 2 as fruit laxative. Nearly all contained Epsom or Rochelle salt without the fact appearing on the label.

One preparation, bearing the A. D. S. label, bears the statement: "This is not a patent medicine, etc.," which raises the question whether a preparation made by a druggist or a group of druggists may not be quite as much a patent medicine as if made by a quack doctor or a seemingly reputable house.

A. D. S. Rheumatic Remedy.—An examination of this preparation by the Experiment Station showed it to contain potassium iodide and sodium salicylate (both well-known specifics for rheumatism) and an alcohol-glycerine infusion of a small amount of an unidentified vegetable drug, to which the trace of alkaloids found may be due.

A summary of the analysis is as follows:

Specific gravity at 15.5° C.....	1.1015
Alcohol by volume	5.70
Solids	23.40
Glycerine	9.80
Ash	7.90
Potassium iodide	6.45
Sodium salicylate	6.13
Alkaloids	trace
Phenolphthalein	absent

The label on the container also gave notice "That this is not a patent medicine."

Dr. Franck's Grains of Health.—Upon examination the "grains of health" proved to be pills of aloes, coated with silver, and costing the consumer at the rate of \$33.19 per pound.

Dr. Williams' Pink Pills for Pale People.—The color of the pills is due to cochineal and the active ingredients detected were iron oxide and magnesium sulphate and a faint trace of alkaloids.

The makers of this nostrum state that the pills are "Not a cure-all" yet on further reading of label we find that they are recommended for all diseases resulting from impoverished blood, a long

list of female complaints, for many nervous disorders, such as St. Vitus' dance, paralysis and locomotor ataxia, and for male disorders arising from excesses, etc.; surely a rather wide field.

Thialion.—In the literature sent to physicians and in its advertisements Thialion is stated to be "a laxative salt of lithia" of the following formula: " $3\text{Li}_2\text{O}$, NaO , So_3 , 7HO ," and sodio-trilithic anhydrosulphate is given as its name. Upon analysis it was shown to be simply a mixture of sodium citrate and sodium sulphate with very small amounts of lithium citrate and sodium chloride.

Poslam.—A grayish ointment with a strong, tarry odor, sold in tin cans containing 20.5 gms., and cost 50 cents. Upon analysis showed the presence of:

Zinc oxide	11.47
Sulphur	6.55
Starch, anhydrous	19.45
Tar oil	14.40
Menthol	present
Salicylic acid	present

Fatty base, probably petrolatum, sufficient to make 100 parts. The active ingredients are zinc oxide, tar oil and sulphur. "These have long been used and known as more or less effectual remedies for the treatment of skin affections, but certainly do not warrant such claims as are made in the advertising matter sent out with Poslam stating it to be 'The newest medical discovery for the treatment of eczema, and all other skin affections and entirely different from anything yet used'" (Puckner and Hilpert).

Since the passage of the Federal Food and Drugs Act Lemon Extract and Asafetida have been much-discussed articles of commerce.

Lemon Extract.—A sample of French's Triple Strength Lemon Extract contained no lemon oil, and was colored with naphthol yellow S, a permitted coal-tar dye. The carton claimed "triple strength," the bottle "genuine extract," and a sticker on both the carton and bottle stated in very fine print that it contained "no" lemon oil, a series of inconsistent and misleading statements clearly making the sample misbranded.

Asafetida, Powdered.—Eleven samples were examined, ten of which failed to come up to U. S. P. requirements for alcohol-

soluble resin and ash content. The U. S. P. allows an ash content of not over 15 per cent. No sample approached even the pharmacopœial maximum and ten contained over 50 per cent. ash. The ash consisted chiefly of calcium sulphate. Another sample, taken on the request of a large wholesaler and guaranteed to contain 61.3 per cent. soluble resin and 16.675 per cent. ash, contained 61.84 per cent. soluble resin and 17.18 per cent. ash, showing that a high-grade powdered asafetida is by no means an impossibility, as often claimed.

THE TREATMENT OF HUMAN CANCER WITH INTRAVENOUS INJECTIONS OF COLLOIDAL COPPER.¹

BY LEO LOEB, C. B. McCLURG, and W. O. SWEET, of St. Louis.²

The experimental study of tumor growth which, as far as its methodical and continued evolution is concerned, originated about twelve years ago, made possible a systematic analysis of the conditions on which the life and growth of the tumor cells depend, and thus laid the foundation for rational investigation aiming at the cure for cancer. Within the last decade many investigators studied the conditions under which an active and passive immunity against tumor growth can be established in the animal body, and the effect of Roentgen rays and of radium on tumor growth. One of us undertook, in 1901 and 1902, the first experiments in which the effect of various chemicals *in vitro* on the vitality of tumor cells was analyzed.³ He found that it is possible to obtain, by grading the strength of such a substance as KCN, a gradual decrease in the virulence of tumor cells. The recent work of v. Wassermann and his collaborators marks a most important step in advance in the treatment of carcinoma in mice. They found that a combination of selenium and eosin, after repeated intravenous injections, caused a rapid retrogression of the tumor. The effective dose was very near the lethal dose of the substance. Neuberg, Caspari and Loehe observed that various solutions of heavy metals caused a disappearance of some animal tumors; but they do not state explicitly what

¹ From the Barnard (Free) Skin and Cancer Hospital, St. Louis, Mo.

² Reprinted from *Interstate Medical Journal*, vol. xix, No. 12.

³ Leo Loeb (*Virchow's Archiv.* Bd. 172, 1903).

kind of substances they used; and although v. Wassermann emphasizes the labile nature of the combination he employed, he does not describe his preparation.⁴ In our first experiments we tested the effect of various copper preparations on mouse carcinoma.⁵ The mouse carcinoma, which we use in our laboratory, is a very rapidly growing tumor, and it occurred to us that human cancer, which in most cases grows much more slowly than our mouse cancer, might be a much more favorable object for testing the efficiency of various substances. We established the lethal dose of our preparation in various species of animals, and then undertook to employ the substance in cases of human cancer.

The first preliminary experiments on human cancer were carried out during May, 1912, with the assistance of Dr. Carroll Smith. During last October and November this work was taken up on a larger scale, and we now wish to report on our result in these later investigations.⁶

We used a colloidal solution of copper prepared according to Bredig's method.⁶ Each patient received daily an intravenous in-

⁴ Caspari and Neuberg (*Deutsch. med. Wochenschr.*, Vol. 38, p. 375, 1912). Neuberg, Caspari and Loehe (*Berl. klin. Wochenschr.*, July 22nd, 1912).

In their first article Caspari and Neuberg refer to a notice in the daily press, according to which Gaube du Gers, in Paris, treated some cases of cancer successfully with heavy metals. After we had begun our work on human cancer we saw in the *Journal of the American Medical Association*, p. 1773, June 8th, 1912, in reply to an inquiry, a statement that Gaube du Gers, in Paris, had used colloidal copper in the treatment of cancer, but that the references to the treatment appeared only in the daily press, and that no scientific account was available. We have been unable to find out what method was used by du Gers, and what his results were. Recently our attention was called, by Dr. W. E. Leighton, to a note by Drs. M. Laurent and J. Bohec in the *Medical Press and Circular*, October 30th, 1912, in which they state that they gave several intravenous and intramuscular injections of colloid selenium in a case of cancer of the stomach. They state that the pain the patient suffered was diminished, and that his general condition improved.

⁵ These investigations are being conducted in conjunction with Dr. M. S. Fleisher and Dr. W. E. Leighton and will be described at a later date.

⁶ During my absence from St. Louis last summer Dr. M. S. Fleisher continued, at my request, these preliminary tests.

Professor E. H. Keiser, of St. Louis, assisted us very kindly in the preparation of various substances which were used. To my colleagues at the Barnard (Free) Skin and Cancer Hospital, especially to Dr. N. B. Carson and to Dr. M. F. Engman, I am much indebted for the interest they are taking in the progress of the work. [Leo Loeb.]

jection of the solution, an average of 300 to 400 c.cm. of the solution, warmed to about body temperature, being slowly introduced. Usually six, sometimes seven, injections were given each week.

The injection is invariably followed by a rise of temperature, which varies usually between 100° and 102° F. Within six hours the temperature again returns to the normal level. The rise of temperature is frequently inaugurated and sometimes followed by a more or less severe chill. By diminishing somewhat the quantity of fluid injected, the chill can frequently be avoided. The reaction becomes less after a certain number of injections have been given. Simultaneously, with a rising temperature, the pulse-rate is usually increased. In certain patients who had a tendency to irregular heart action before the treatment was begun this irregularity may be accentuated a few hours after the injection. Otherwise, no notable changes, so far, have been observed after the injection.

On the whole, patients tolerate these injections very well, and their general condition (appetite, strength, complexion) improves. The number of erythrocytes does not decrease, but, on the contrary, probably shows a definite increase.

Effects on the Tumor.—About two to four hours after an injection, hyperemia is noticeable in the tissue adjoining the tumor. If the tumor is open, this hyperemia is accompanied and followed by an increased secretion from the ulcerated part of the tumor. The hyperemia recurs after each injection in the beginning of the treatment, and then gradually diminishes, the increase of discharge of fluid usually ceasing three to four days after the first few injections. Accompanying the hyperemia there is present an increased sensitiveness of the tumor. After about fifteen injections the increased hyperemia and sensitiveness disappear, and the discharge becomes much less marked than it was before the beginning of the treatment. There exist, of course, some quantitative variations in the appearance and duration of these symptoms. In the report of the individual cases some of these variations will be referred to. Very noticeable was the diminution in the pain caused by the cancer, and there was no necessity of continuing the use of narcotics. The intravenous injections caused a gradual necrosis and resorption, or sloughing, of the tumor, which usually proceeds not very rapidly but continuously. In some cases a gradual diminution in the degree of retrogression of the tumor was noticeable; but so far the retrogression has been continuous, and, at least, two of our cases are very near a complete cure.

We are hopeful that all the cases we are treating will be cured, although we cannot make as yet any definite statement concerning their ultimate fate.

We selected for our treatment, especially, cases in which the changes taking place in the tumor could be followed with the naked eye, but included also a few other cases, upon which we shall report later. All our cases, with one exception, had been operated upon before without success; several had been treated with Roentgen rays, likewise unsuccessfully; in one case the patient had not been operated upon previous to the injection, but had been treated unsuccessfully with Roentgen rays and other means. All the cases were almost hopeless as far as effect of any other surgical or dermatological treatment was concerned.

THE OIL FROM SPURIOUS CUBEBS.¹

We learn from an article by J. C. Umney and H. V. Potter² that a parcel of cubebs imported from Macassar into Amsterdam, and distilled there, yielded an oil which attracted attention by its extraordinarily low optical rotation. Whereas this value ranges normally from -25 to -40° ³, in the oil in question it was only -14° . The cubebs themselves appeared to be in most respects normal, but the odor was mace-like.

The abnormality of this oil led the authors to make some enquiries as to the cubebs present on the London and Amsterdam drug markets, with the unsatisfactory result that out of eight samples examined, only four proved to be genuine cubebs. Three samples consisted of other species of cubebs, while one contained an admixture of other fruits. Part of the samples was also largely adulterated with stalks, in one instance to the extent of 46 p. c. The spurious cubebs differed from the genuine both by their mace-like odor and by the result of the sulphuric acid test. For when the fruit, crushed in a porcelain basin, was moistened with a little concentrated sulphuric acid, the genuine samples quickly showed a beautiful crimson color, while in the case of the false fruits the

¹ From *Semi-Annual Report* of Schimmel & Co., October, 1912, pp. 50-52.

² *Chemist and Druggist*, 80 (1912), 331, 443.

³ Umney and Potter give -30° as the maximum limit of value. This is probably a misprint.

color was yellowish brown. It is stated that the difference is still more easily perceptible in the ethereal extract of the fruit, of which extract, moreover, the genuine cubebs yield more (20 to 25 p. c.) than does the spurious fruit (only about 15 p. c.). There was also a difference in the microscopical characters of the various species.

The authors suspect that the spurious cubebs consist partly of the fruit of *Piper ribesoides*, Wall. and partly of an as yet unknown variety of *Piper*. The latter, when subjected to steam distillation,⁴ yielded 4 p. c. of essential oil of a decided mace odor: d 0.894, $n_D^{20} + 16^\circ$, sap. v. o, ester v. after acetyl. 56.1. Genuine cubebs, distilled for purposes of comparison, yielded more than twice that percentage of oil with sp. g. 0.917, and opt. rot. -43° .

The behavior under fractionation of the two distillates also showed marked differences. The oil from the spurious cubebs began to boil below 160° ; one-half of it passed over up to 200° , and a further 30 p. c. between 200° and 270° . On the other hand, of the oil from the genuine cubebs, only 5 p. c. passed over below 200° , 85 p. c. passing over between 200 and 270° .

The surmise that the false fruits might be identical with those of *Piper Lowong*, Bl., which were distilled by Peinemann⁵ several years ago, proved to be unfounded, the microscopical structure of the two *Piper*-species being entirely different. Umney and Potter conclude that certain of the abnormal oils of commerce are produced from mixtures of the genuine berries either with this hitherto unidentified, or with other varieties. This would also explain the abnormality of the Amsterdam oil referred to at the beginning of this paragraph.

J. Small⁶ and E. M. Holmes⁷ also give their views on the same subject. Small has examined several authentic samples of genuine and spurious cubebs, placed at his disposal by the Herbarium and the Museum in London of the Pharmaceutical Society, and, basing himself upon his observations on these, has examined a number of commercial samples.

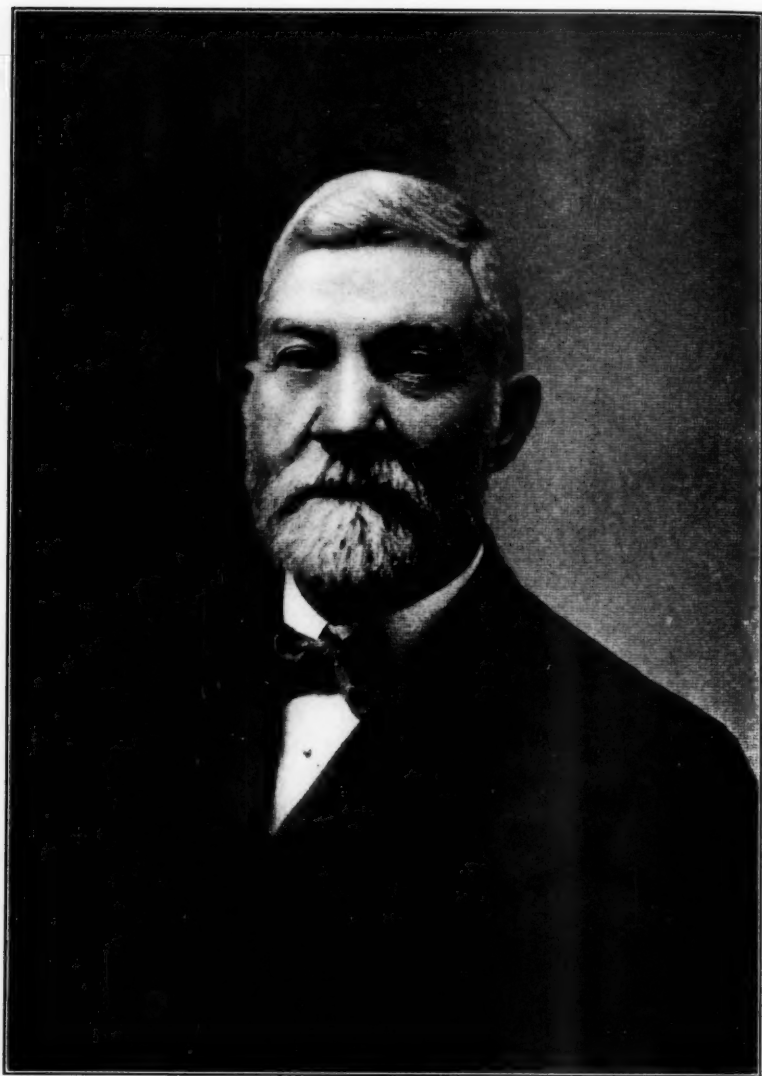
The articles by Holmes and Small are of purely pharmacognostical interest, and for particulars of their contents we must therefore refer to the originals.

⁴ *Perfum. and Essent. Oil Record*, 3 (1912), 64.

⁵ *Arch. der Pharm.*, 234 (1896), 238.

⁶ *Pharmaceutical Journ.*, 88 (1912), 639.

⁷ *Perfum. and Essent. Oil Record*, 3 (1912), 125.



WILLIAM MCINTYRE, 1843-1913